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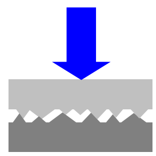
Resistance Welding - Effect of Weld Impact Force on Weld Heat

By David Steinmeier

Introduction

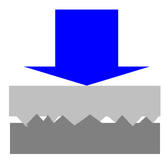
Weld force is a key variable in the resistance welding process. Weld force clamps the weld parts together to provide a path for the weld current. Weld force also affects the heating produced by the:

- Electrode-to-part contact resistance
- Part-to-part contact resistance



Low weld force produces:

- High contact resistance
- Increased weld heat



High weld force produces

- Low contact resistance
- Decreased weld heat

Weld Force Components

The word “weld force” usually brings to mind the static force that clamps the parts together. In reality, there are two components that comprise weld force, both of which can affect the weld heat:

- Weld impact force
- Weld clamping force

Weld Impact Force

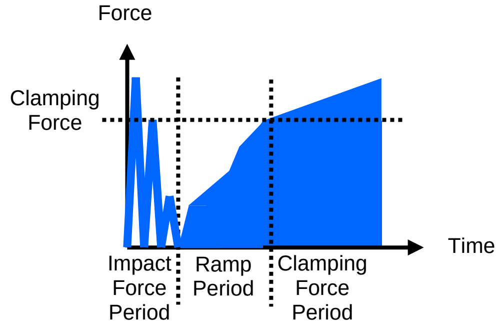
When a moving electrode contacts the stationary weld parts, the electrode impacts the part surface, deforming the part. This impact force reduces the electrode-to-part and part-to-part contact resistances. This decrease in contact resistances reduces the weld heat. A faster moving electrode will have a greater impact force and thus a greater affect on weld heat.

Weld Clamping Force

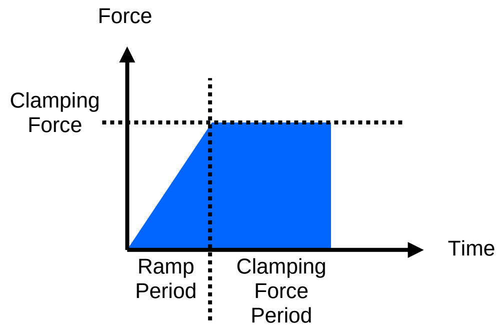
Once the moving electrode has impacted the stationary parts, the weld force should stabilize at a set value called the clamping force. The clamping force is normally one of the input factors used to develop an optimized welding process.

Modern weld head design employing compression springs that are air or servo motor actuated provide stable clamping force after the initial weld impact force has dissipated. Magnetic (linear motor) weld head technology also provides excellent clamping force control and stability.

The following graph represents weld force measured over time for a weld head with no impact or clamping force control. Note the oscillating impact force caused by the electrode impact on the top part. Also note the lack of constant weld force during clamping force period.



This graph represents weld force versus time for a weld head with impact and clamping force control.



Weld Impact Force Control

Magnetic, servo motor, and cam driven weld heads provide complete control over the weld impact force by controlling the electrode speed. Typically, the electrode descends very rapidly from the retracted position to a search position just above the parts at a programmed velocity. From the search position to the parts, the programmed velocity is typically one-tenth of the previous electrode speed. Thus, the moving electrode contacts the parts at a known and consistent velocity so the impact force is consistent from weld-to-weld.

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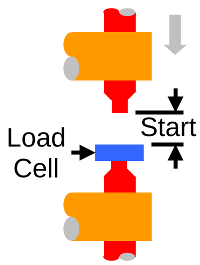
Air Actuated Weld Force Impact Control

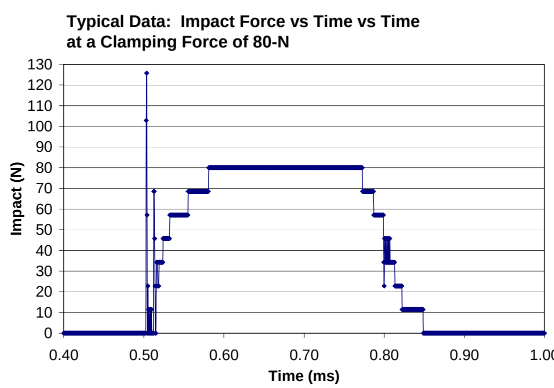
Air actuated weld heads control the electrode speed by limiting the air flow to the air actuation cylinder. Typically, the operator closes the needle value on the air flow regulator and then opens the needle valve a defined number of turns. There are several problems associated with the "needle valve turns" method:

1. The electrode speed varies with changes in the air supply tubing length or air source pressure.
2. Setting up identical welding stations is difficult.
3. The electrode speed changes with bearing wear.
4. The distance between the electrode tip and the weld parts in the retracted position must be measured and kept constant. A larger travel distance may result in a larger impact force.

Simple Measurement Solution

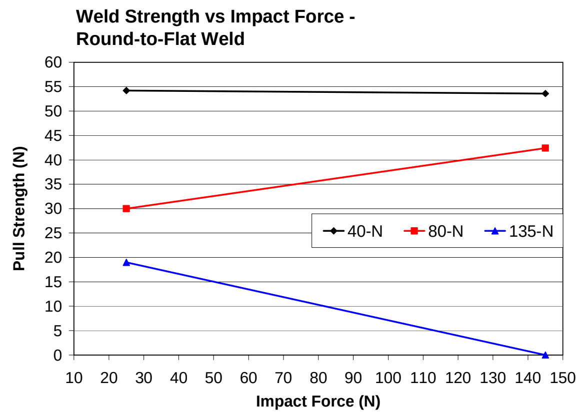
Use a load cell to measure and set the impact force. The load cell measurement system must be able to gather force data at a minimum rate of 1 sample per every 0.5-milli-seconds in order to capture the peak impact force. Rest the load cell on the stationary electrode and impact the load cell with the moving electrode. Set the impact force by adjusting the needle valve.





Weld Impact Force Investigation

To investigate the effect of weld impact force on weld pull strength, microJoining Solutions conducted a full factorial design of experiment (DoE), welding 0.4-mm diameter nickel alloy 200 wire to 0.15-mm thick by 4-mm wide nickel ribbon. The weld current/time profile was fixed during the test. The clamping force was varied from 40 to 135-N. The impact force was varied from 25 to 135-N. The results are displayed in the following interaction graph.



The Balanced ANOVA DoE results for this particular application revealed that the clamping force is the prime input factor, contributing 79.5% to the average pull strength. The interaction contribution of the clamping force and impact force is 9.9%. The impact force is inconsequential at 0.3%. The Adjusted R-Squared Value is 87.57%, indicating a good fit with the ANOVA "means" model. For maximum pull strength, this application requires a clamping force of 40-N. At this setting, the impact force can range from 25 to 135-N with minimal effect on the pull strength.

Unlike the 40-N and 134-N clamping force curves, the 80-N clamping force curve pull strength increases with higher impact force. A possible explanation for the 80-N results can be found by the examining the actual weld mark. The higher impact force weld contact area is 34% larger than the lower impact force area, thus providing more pull strength.

Photo 1 - 80-N Clamping force, lowest impact force

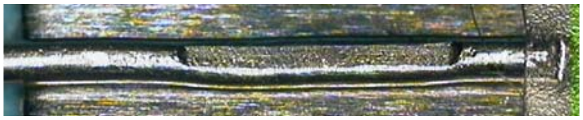


Photo 2 - 80-N Clamping force, highest impact force

Conclusion:

Depending on the application, impact force may be an important input factor in the welding process. Dynamically set and measure both the impact and clamping forces to ensure correct process set up and weld quality results.